

# The Illinois Chemistry Teacher

*A Journal*

*The Illinois Association of Chemistry Teachers*

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Number 1

## Modern Alchemy

By George L. Clark

Professor of Chemistry, University of Illinois

Several hundred years ago the science of chemistry began as a series of attempts to transmute base metals into gold and other precious metals. All those attempts of honest men and of charlatans, who were far in the majority, proved to be fruitless. Thus arose the great principle of the finality and immutability of the atom as the ultimate unit of matter. For more than a hundred years chemistry and physics were built around the concept of the indivisibility and permanent stability of atoms. This fundamental concept has remained down into the memory of all of us.

The ultimate permanence of atoms of course received a serious blow with the discovery of radioactivity or the process of spontaneous breakdown of some of the heaviest atoms whose hearts or nuclei were so complicated as to be unstable and yet, here again man seemingly was helpless by his puny methods to affect in any way the process of radioactive disintegration. The forces and energies involved seemed far beyond the power of any man to produce or control.

Now upon the world's stage we look upon a most astonishing state of affairs. Chemists and physicists have become alchemists in the direct sense of the word, as they have discovered from long persistent inquiry that, after all, these atomic hearts are vulnerable to bombardment.

Man has within his power to control and utilize infinitely small projectiles of unbelievable energy and velocity.

Only a few short months ago we could write down as the fundamental unit particles from within the universe is constructed the following:

The **electron**, or the unit of negative electricity.

The **proton**, or the heart of the hydrogen atom with a single positive charge and a mass slightly greater than one as compared with the mass of the oxygen atom considered as sixteen.

Everything material in the whole universe thus was to be considered built up from the proper combination of electrons and protons. For example, the oxygen atom has a minute nucleus in which the mass is concentrated, built from sixteen protons, held together by eight electrons, while around this nucleus as a sort of planetary system are to be found eight outer electrons. To these two unit fundamental particles might be added the **alpha** particle produced by radioactive atoms, which is really the heart of a helium atom and which acts apparently as a stable unit in itself although obviously consisting of four protons condensed together to form the helium nucleus; and the **photon**, or the unit particle of radiation as distinguished from the wave properties of radiation which

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## THE ILLINOIS CHEMISTRY TEACHER

A Journal of  
THE ILLINOIS STATE ASSOCIATION OF  
CHEMISTRY TEACHERS  
Normal, Illinois

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In presenting The Illinois Chemistry Teacher as a part of the service of the Illinois Association of Chemistry Teachers we feel that we are providing a medium for the interchange of worthwhile ideas, for the carrying to the teachers of this state the valuable material presented at the meetings of the association, and for presenting, so far as the limitations of the publication permits, some of the best thought in the teaching of chemistry. The aim is to stimulate and promote progress in the teaching of chemistry.

### Knox College a Unique Institution

Knox College, host to the Illinois Association of Chemistry Teachers at the Mid-Year Meeting, is noted not only for the outstanding work carried on there particularly in the field of science but also for the way it is linked with the history of the state. Among other things, it is the site of one of those famous historical Lincoln-Douglas debates of 1858. For the occasion of Founder's Day, which it celebrated February 15, in honor of its "first" ninety-seven years, "Old Main" was restored in appearance to that of those historic times. The restoration involved an interesting chemical process. Chemistry teachers of the state will be interested to learn more of the restoration, the chemical process involved, and also to get better acquainted with the situation as it is today.

The members of this association certainly appreciate the cordial invitation extended by Knox College to hold the Mid-Year Meeting there and also the help of Professor John C. Hessler of that institution in making the necessary local arrangements.

—:—

### The Science Program Under Criticism

The progressive chemistry teacher that wants to keep abreast of the educational movement will not want to miss the stimulus provided by the Thirty-first Yearbook (part 1) of the National Society for the Study of Education. This book, entitled A Program for Teaching Science, attacks many of the traditional principles now venerable with age which many of us may still be inclined to accept and shows them to be fundamentally wrong. The challenge is sufficient to jolt us from our present "rut" long enough for us to question what should be a part of the science course and what are the objectives about which it should be built. Fundamental objectives of each of the sciences are presented and plans are given for developing courses to better serve the needs of the people. The contributors to the book are among the leaders in the field of science education. The book is published by the Public School Publishing Company, Bloomington, Illinois.

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## Chemistry in the Reconstruction Period

The progressive chemistry teacher is always instructing ten or fifteen years ahead of his generation. Before "dry ice" appeared, chemistry teachers were demonstrating carbon dioxide snow. Cellulose plastics appeared in school laboratories before rayon and cellophane were market realities. Nitrogen fixation was a topic of elementary chemistry before the great nitrogen industry appeared. Science teachers are largely responsible for the acceptance by the public of the germ explanation of many diseases. Without such basic scientific instruction in our schools scientific progress would be impeded or quite impossible.

The high school teacher of chemistry has a premier opportunity today, for in the coming new order, chemistry will doubtless play a larger part than in the old. The closing period was one of great development through mechanical triumphs. It was rightly called the machine age. Goods were produced largely through mechanical transformations of raw materials. We have reached the zenith of this development. We have more capacity for such transformations than we can use at present. We are entering the chemical age in which the transformations of matter are to be more and more those involving changes in chemical constitution. This shift, already so apparent to the scientific mind, is to become more and more marked with the passing of the years.

The changing order opens at least two unparalleled opportunities to the teacher of chemistry. First: he has the dissemination of a body of knowledge which is daily growing more and more useful to the race. Few, if any subjects in the curriculum can match it in this respect. This knowledge is not that of a past age, rather it belongs to the present and the future. What it is to do for the race, and what the race will do with it cannot yet be imagined. Second: it becomes the opportunity of the teacher to search out young life in which is the divine spark of a Faraday or Langmuir and to set

the feet of such in the way of service to the race through attainments in chemical science. Just as the Battle of Waterloo was won on the school grounds of Rugby, so the racial triumphs of the years ahead are to be fought out in the science classrooms and laboratories of the schools today.

HOWARD W. ADAMS

Illinois State Normal University

### Hand Book of Chemistry and Physics

The New Handbook of Chemistry and Physics just published by the Chemical Rubber Company is to be commended for completeness of the scientific material presented and the great variety of topics covered. The table of solubilities and boiling points is essential to answer with satisfaction the questions that come from the "wide awake" students and also to meet intelligently the problems that occur in the laboratory. Just how a teacher can succeed well in directing project work and the laboratory problems that are now so much in vogue with out the aid of a set of tables such as are presented in the Handbook is rather questionable unless the work is of the "thumb rule" type. Furthermore the facility gained in using a set of tables of scientific data and information to answer questions that arise, as well as solve original laboratory problems, is worth as much to the student as is much of the work presented in the chemistry course.

### Wilkens-Anderson Extends Service

It is interesting to know that the Wilkens-Anderson Company which formerly devoted its services almost exclusively to the colleges and universities has extended its service to the high schools. This assures the science departments of the high schools a supply of dependable high grade apparatus, glass ware, and chemicals at a reasonable cost. Their general catalogue may be obtained by writing for it.

We wish to call your attention to the advertisers using this publication. All are presenting goods of unquestionable merit and are deserving of consideration. Moreover, they not only have expressed themselves as friendly toward this enterprise but have proved it by using our columns for advertising.

## Discovery of the Composition of Water

UNIVERSITY OF ILLINOIS

WILLIAM ALBERT NOYES

URBANA, ILLINOIS

Abstract of a lecture given before the Chemical Section of the Division of Physical Sciences of the High School Conference, November 24, 1933.

When students read in their textbooks that water is composed of oxygen and hydrogen; that the composition is approximately eight parts by weight of oxygen for one part of hydrogen; and later that the atomic weight of hydrogen is 1.0078, they do not realize that these facts are the result of the work of more than one hundred different men. Some of these men spent many years on the problem. At least a half dozen of our prominent chemists in the United States are working today on a new phase of this subject, which has come to their notice during the last three years.

We may well take as the first beginning, the discovery of hydrogen three hundred years ago not far from the time when the Pilgrim fathers came to Massachusetts. So little was known about gases of any sort that van Helmont, the Dutch chemist who made the discovery, invented the word gas. He was still something of an alchemist and his ideas about many things were so crude that he said, and evidently believed, that "if you set aside some grains of wheat and some soiled linen they will generate mice—not little ones but full size and running about!"

On Aug. 1st, 1774 Priestly first prepared oxygen by heating red oxide of mercury. Soon after, Lavoisier, in Paris, heated some mercury in a retort connected with a bell jar containing air until the volume ceased to diminish after the experiment had been continued for several weeks. He collected the oxide of mercury formed and by beating it recovered the oxygen that had been absorbed and proved that it was one-fifth of the volume of the air.

Priestley called oxygen "dephlogisticated air" a name based on the belief that phlogiston is given out when substances burn and that ordinary air had lost a large part of its ability to support combustion for this reason. Oxygen

was supposed to be pure "vital air" without the phlogiston which air contained. Priestley and also Cavendish very soon tried experiments in which mixtures of oxygen and hydrogen (called "inflammable air") were exploded and water was formed. Water before this had been universally considered a simple substance—indeed it was one of the four elements of the ancients. The followers of the phlogiston theory were slow to grasp the full significance of their results but Watt, the inventor of the steam engine, stated very soon that water is a compound. Cavendish also determined accurately that one volume of oxygen combines with two volumes of hydrogen and also weighed the water formed. His experimental work was exceedingly accurate for his time but he did not know the weight of a given volume of hydrogen and an accurate determination of the composition of water could not be calculated. Lavoisier very promptly heard of the English experiments and repeated them. He seems to have been the first to give a clear statement that water is a compound of oxygen and inflammable air—an excellent illustration of the fact that the interpretation of results is quite as important as accurate experiments. Lavoisier also determined the composition of water by boiling some water, passing the steam over red hot iron, condensing the water which was not decomposed and collecting the hydrogen. From the weight of the water decomposed and the volume of the hydrogen, together with the weight of a given volume of hydrogen, the composition of water was calculated. In these results the weight of the hydrogen was not well enough known to give a good result.

The first fairly accurate determination of the composition of water was made by Dulong and Berzelius in 1821. They passed pure hydrogen over heated copper oxide and collected the water formed. The weight of the oxygen was known from the loss in weight of the  
(Continued on page 14)



# The Motoin Pictures For Industrial Plant Trips

BLOOMINGTON HIGH SCHOOL

S. A. CHESTER

BLOOMINGTON, ILLINOIS

If you are not so fortunate as to have within the community where you teach an opportunity to take your students into industrial establishments where they may see chemistry in action, you will probably appreciate the possibilities in the use of motion pictures. Many schools now have a 16 mm. projector. We are listing here some of the sources and a sampling of good film titles available in the 16 mm. safety type. Any of these agencies will be glad to furnish catalogs of their films.

## SOURCES

1—General Electric Co., 230 S. Clark St., Chicago Ill.

2—U. S. Bureau of Mines, 4800 Forbes St., Pittsburg, Pa.

3—American Museum of Natural History, 77th & Central Pk. West, New York.

4—Y. M. C. A. Motion Picture Bureau, 19 S. LaSalle St., Chicago, Ill.

5—Films of Commerce, Inc., 35 W. 45th St., New York, N. Y.

6—Iowa State College, Ames, Iowa, Visual Instruction Service.

7—University of Wisconsin, Madison, Wis., Bureau of Visual Instruction.

8—University of Iowa, Iowa City, Iowa, Dept. of Visual Instruction.

9—Indiana University, Bloomington, Ind., Bureau of Visual Instruction.

10—Illinois Dept. of Public Health, Springfield, Ill.

The following list of films is by no means complete. It is intended to give an idea of the excellent material available. In many cases the films are loaned free except for transportation charges. Some of the films from the university are loaned on a low rental basis. This rate is usually \$1 per reel.

Reels	Title	Material	Sources
1	Beyond the Microscope .....	Atomic Structure .....	1
1	Pillars of Salt .....	Salt Mining, Refining .....	1-6
1	Liquid Air .....	Demonstrations .....	1
2	Sulphur .....	Mining and Uses .....	2-3-6
3	Manufactured Abrasives .....	Carborundum .....	2
3	Story of Lead Mining and Milling .....	.....	2
1	Carbon Monoxide, The Unseen Danger .....	.....	2
4	Refining the Crude .....	Petroleum Industry .....	2
4	Story of Steel .....	Complete Manufacturing Process .....	2
2	Metals of a Motor Car .....	Alloys .....	2
1	Soap .....	Hard Water, Soap Manufacture, and Uses .....	9
1	Bacteria .....	Culture, Growth, Effects on Man .....	10
1	Rubber .....	Rubber Harvesting and Manufacture .....	9
1	Fire Making .....	Science of Combustion .....	9
1	Refrigeration .....	Modern Methods Explained .....	9-6
2	Romance of Rayon .....	From Cotton to Rayon Cloth .....	9-3
1	Glass Blowing Technique .....	.....	9
2	Story of a Storage Battery .....	History and Manufacture .....	3
2	Steel—Mining and Metallurgy .....	.....	3
2	Cane Sugar .....	Complete Manufacture .....	5-4
1	Romance of Glass .....	Discovery and Development of Mfg. ....	4
1	Mountain to Cement Sack .....	Manufacture of Portland Cement .....	4
2	From Pigs to Paint .....	Story of Dutch Boy White Lead .....	4
2	Story of Bakelite Resenoid .....	.....	4
1	Molecular Theory of Matter \$2 .....	(Can be shown silent) .....	6
1	Oxidation and Reduction \$2 .....	(Can be shown silent) .....	6
1	Mining and Smelting of Copper .....	.....	7
1	Pig Iron to Steel .....	.....	7
1	Silver .....	Refining, Plating, Photography .....	7
1	Tin .....	Mining, Manufacture, Uses .....	7
1	Chemical Effects of Electricity .....	.....	7
1	Purifying of Water .....	.....	7
1	Sewage Disposal .....	.....	7
1	Four-Stroke Cycle Gas Engine .....	.....	7

## Laboratory Assistants

LAWRENCE E. DODGE

GILLESPIE COMMUNITY HIGH SCHOOL

GILLESPIE ILLINOIS

Most high school chemistry teachers need more time for checking reports, setting up apparatus for demonstrations, and doing the other work incidental to teaching the course. At the same time they do not wish to neglect laboratory instruction, a very important and essential part of every course, particularly one in chemistry. However, as the class enrollment increases, the demands upon the instructor's time also increase and handicap the instruction, especially in the laboratory.

Any system or plan which will aid the overburdened instructor in directing laboratory work, must be one which is simple in form, flexible in character to meet the changing demands of the department, and easy to put into operation. It must also be a plan that will increase the instructor's control of his classes without increasing proportionally his efforts. Such a system, that of laboratory assistants, has been used successfully for eight years in the Gillespie Community High School.

The system as it now operates consists of five members, all seniors. (These boys had served at least one semester's apprenticeship during their junior year.) At the beginning of the school year the senior assistants elected one of their members to act as chief-of-staff. This assistant has complete control of the laboratory work. He outlines a work schedule which lists the hours of work apportioned to each assistant and also their respective duties.

In the afternoons the assistants spend more time in the stockroom checking out materials to qualitative analysis students. As the occasion demands, the assistants are relieved from laboratory duty to check, clean, and repair apparatus and equipment. Whenever a motion picture is to be shown, the assistants act as the operators. They clean and oil the machine, test the film, put up the screen, and see that everything is in perfect condition. If slides are to be shown, the

balopticon is focused and the slides are arranged in order to agree with the lecture notes.

The duties of the assistants do not end with the close of the afternoon session of school. They then leave the routine laboratory tasks and become clerical assistants. Daily work, problems, and short quizzes are checked and graded. In the experimental, or laboratory reports, the assistants check the chemical equations and the answers to specific questions. They correct the drawings and grade the problems. Any peculiarities found in the papers graded are reported to the instructor. Make up work is also put into the hands of the assistants. The student who has been absent, is asked to report to an assistant, designated by the instructor. The student is coached and trained in class room work, and is given help in working out any experiments he may have missed. On Saturday mornings a chemical clinic is held for the assistants. The work of the past week is reviewed and plans formulated for future work. The instructor and assistants work together in performing experiments relative to laboratory work, and the chief-of-staff receives his instructions for future work from the instructor at this time.

From the nature of the work done it is necessary that the assistants be chosen very carefully. The qualities desired might be classified under the following headings:

**Mental.** It is highly important that the mentality of the prospective assistants be of a high order. His previous scholastic record and the ease with which he masters his scientific subjects should offer fair standards for judgment in this respect. The proverbial "book-worm" does not always make an excellent assistant since he quite often lacks the ability to make practical applications of his theoretical knowledge.

**Manual.** Since the assistants will be required to show others how to set up apparatus and work with chemicals he

should show that he, himself, is careful, though rapid in his work. Further he should show that orderliness and neatness are inherent qualities and that he can work with his hands.

**Moral.** In scientific work honesty, integrity, truthfulness, and other moral virtues are essential. The potential assistant should possess a goodly number of moral qualities since he will be subjected to many powerful forces such as jealousy, unjust criticism, and inter-group friendship.

**Health.** An assistant should be **very healthy**. No work takes such a toll of bodily energy as does that of laboratory and classroom.

**Personality.** Along with all the other needed characteristics, an assistant should have a pleasing personality, a personality which aids the student in working for the instructor and with the other students in the department.

It is advisable to choose juniors as potential assistants and to make the selections some time near the end of the first semester. These juniors are apprenticed to the senior assistants who train them thoroughly in the routine duties of the laboratory.

After reading the description of the system as it operates at the present time it may appear that there is some reason to doubt several of the introductory statements which read: "easy to put into operation," and "simple in form".

The student assistant system is easy to put into operation because it represents a development from one student. The first student, the nucleus of the system, should be chosen very carefully and trained very thoroughly in the methods used by the instructor. As soon as the first assistant has shown sufficient proficiency to work independently a second student is chosen. New members may be added only when the old members have demonstrated that they are capable of doing the work assigned. The simplicity of the system is best shown by a diagram:—

Instructor  
Chief-of- staff  
Four senior assistants  
Four junior apprentices  
Members of science classes

The assistants act as liaison officers, making possible more harmonious working relationship within the department. The instructor will find that it is possible, through the assistants, to obtain a greater appreciation of the problems confronting the individual students of the science classes.

The system is exceedingly flexible since the duties of the assistants can be altered in character at a moment's notice to meet the needs of the department and the requirements of the instructor.

What is the instructor's part in the student assistant system? The instructor might well be considered as the commanding officer or director. While he is not in direct contact with every student in the department every minute of the day still he is kept informed of every occurrence in the department.

In beginning the students assistant system, the instructor will have more work to do because certain essential materials must be provided for the assistants' use. Some of the materials required are:

1. Answer sheets to accompany:
  - a. daily work
  - b. one word quizzes
  - c. short exams (ten minute type)
  - d. true and false tests
  - e. problems
2. Record books in which to record the grades of:
  - a. laboratory experiments
  - b. written work

The record book contains the names of the students in the science classes together with the experiment numbers. By reference to the experiment record book the instructor can tell at a glance the progress made by each student in the laboratory. A considerable number of the materials listed above may be saved and used from year to year.

Last but not least, how are the assistants paid? It is well to offer some incentive to assistants to do good work in spite of the fact that some students because of the interest in their science courses would be glad to work simply for the joy of working. An increase in grade could be given to assistants for work well

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**SILVERPLATING AS A PROJECT****H. L. Silchenmyer**

Bloomington High School

Students often find electroplating an interesting chemical project. Such articles as knives, spoons, articles of jewelry, parts of musical instruments, or of the radio may be silverplated by even an amateur. On carrying out the process the student gains a practical knowledge of the chemistry involved.

The first and most important operation in the electroplating of metals is a thorough chemical cleansing of the surface of the metal to be plated, for if this is not accomplished the metal will not adhere to the surface.

Before cleansing the article, it should be trussed with copper wire to avoid the necessity of handling it during the cleansing and plating processes. A slight contact with the hands makes a second cleansing necessary. The object to be plated, when clean, should be placed directly in the plating solution, as the surface of the cleaned material soon becomes coated with a film when exposed to the air.

If the surface to be plated is rough, the deposit will have a dull luster, while if the surface is smooth the deposit will be bright.

The following process may be used for cleansing a copper or brass object. The article to be cleaned is placed in an acid solution prepared as follows: Water, 10 parts; nitric acid, 5 parts; and sulfuric acid, 10 parts. This part of the cleansing may be accompanied by occasional rubbing with sand or pumice stone powder. The article is then removed and rinsed in distilled water. The cleansing is continued by placing it in a hot concentrated sodium carbonate solution. This is followed by rinsing it in distilled water and dipping it in a dilute solution of potassium cyanide. If a thin film of the solution completely covers the surface of the object and does not collect in drops when removed from the solution the object is clean, and should be immediately placed in the plating solution. However, if the solution does collect in drops upon the surface of the object, it is an indication that the ob-

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**ENRICHED CHEMISTRY COURSE****John C. Chiddix**

Normal Community High School

Normal, Illinois

Chemistry becomes more interesting to students as their concepts of and experiences with chemical phenomena are built up. With an increased fund of information the work takes on more meaning until the students finally are able to solve some of their own problems in terms of chemical principles. To hasten the process of acquiring a necessary background of information and also to broaden it, supplementary reading in books written for the layman will be found of much value.

For the slow and uninterested student, an interesting article that he can understand and that deals with the ideas he is trying to grasp will both help him to succeed and stimulate him to read more. For example, any student that is having difficulty understanding how atoms react will take increased interest after reading the chapter entitled *Gentlemen Prefer Blondes* in Kendall's *At Home Among the Atoms*.

The gifted student who usually suffers because he is neglected and who has his initiative stifled by lack of something to achieve needs the stimulus of more difficult problems to challenge his understanding. Such a student would enjoy *Up from the Microcosmos* in Shapley's *Flights from Chaos*.

Below is given a list of suggested readings to be used in connection with the study of the atom and its activity.

**Atoms and Their Activity**Kendall, James. *At Home Among the Atoms*.

The Century Company, New York. 1929.

Bohrville, Chapter 20.

*Gentlemen Prefer Blondes*, Chapter 11.

Valencia, Chapter 10.

Mill, John. *Within the Atom*.

D. Van Nostrand Company, New York, 1923.

*Satisfied and Unsatisfied Systems*, Chapter 2.

(Continued on page 13)



# Program of Meeting

*of*

## ILLINOIS ASSOCIATION OF CHEMISTRY TEACHERS

*Knox College, Galesburg, Illinois*

*Saturday, March 3, 1934*

**Morning, 10:00 o'clock**

Chairman — Glen Tilbury, Urbana High School

Business Session

Demmonstrations — Chemical Faculty, Knox College, Galesburg.

Chemistry in the Industries of the Peoria Region — George C. Ashman,  
Bradley Polytechnic Institute, Peoria.

(The talk will include the brewing and distilling industries, metallurgy, etc.)

**Noon, 12:30 o'clock**

Luncheon (Place to be announced at meeting)

**Afternoon, 1:30 o'clock**

Chairman — John C. Hessler, Knox College, Galesburg.

The Chemistry Teacher's Contribution to Modern Culture — Dr. Otto Reinmuth, Editor of the Journal of Chemical Education, University of Chicago.

Guiding Students in Preparation for the Contest of the Junior Academy of Science — Rose M. Cassidy, Maine Township High School, DesPlaines.

Report of Research on Problem Solving Technique for Laboratory Work — H. Waldo Horrabin, Western Illinois State Teachers College, Macomb.

A Unit Organization for Teaching High School Chemistry — L. T. Lucas, J. Sterling Morton High School, Cicero.

Reservations for the luncheon should be sent in at once to Professor John C. Hessler of Knox College, Galesburg, Illinois. Professor Hessler is in charge of all local arrangements. He announces that excellent hotel accomodations may be obtained at either the Custer or Broadview Hotel of Galesburg.

## MODERN ALCHEMY

(continued from page 1)

is, in a sense, only a non-material messenger of the proton and the electron.

Very few people ever dreamed that there could be found or even that there existed any other fundamental units since these seemed to be adequate to explain matter and radiation energy. But now in 1934, behold the list of fundamental ultimate building stones of the universe:

1. The proton.
2. The alpha particle.
3. The negatron, formerly called the electron.
4. The positron, a single unit positive charge of electricity dissociated from mass.
5. The neutron, a close-coupled positive and negative charge giving a particle of neutral charge.
6. The deuteron or nucleus of the heavy isotope of hydrogen  $H^2$  or deuterium which is present in "heavy water".
7. The triton or nucleus of the rare  $H^3$  isotope or tritium.

The discovery of the neutron and the positron came as a result of attempts to transmute one chemical element to another by bombarding atomic nuclei with alpha particles from radioactive materials, or with high speed protons. About two years ago Bothe and Becker, working in the German Reichsanstalt discovered that some kind of very penetrating rays, supposedly like the therapeutic gamma rays, or x-rays of short wave length, were emitted when beryllium atoms, especially, were bombarded by alpha particles from polonium. The phenomenon was further studied by Curie and Joliot in the Paris Radium laboratory. It remained, however, for Chadwick and coworkers in the Cavendish Laboratory in England, under the direction of Sir Ernest Rutherford, to demonstrate that these penetrating rays are electrically neutral and are neutrons, which are produced by reaction like this:

$Beryllium^9 + Helium^4 (\alpha) = Carbon^{12} + Neutron^1$ . These neutrons produced by bombardment, are in turn capable of acting as disrupting projec-

tiles, for when one of them collides with the nucleus of a nitrogen atom this nucleus is shattered into boron and helium atomic nuclei, whose tracks may easily be identified. The process is probably  $N^{14} + n^1 = B^{10} + He^4$ . In some cases the neutron is not captured and the disintegration is  $N^{14} = B^{10} + He^4$ . Neon nuclei are disrupted in accordance with equation  $Ne^{20} + n^1 = O^{16} + He^4$ . Similarly if these neutrons pass through any material containing hydrogen, such as paraffin wax or water, protons are ejected. The neutron has a relative mass very slightly greater than 1.

The discovery of the positron, or positively charged twin sister of the negative electron, was announced by Professor Anderson of the California Institute of Technology a short time ago. Very recently its presence in cosmic rays was confirmed in the Cavendish Laboratory by Blackett.

In addition to the sensational discovery of these two new fundamental entities, the neutron and the positron, and the two heavy isotopes of hydrogen, remarkable alchemical feats are being performed today in which the familiar proton (which now appears to be a neutron plus a positron,) serves as the projectile. No less remarkable than the fact that protons moving at high speeds can disrupt atomic nuclei and change one element to another, are the ingenious methods by means of which these protons can be given enormous kinetic energies, up to 3,000,000 electron volts so far.

Cockroft and Walton in England were the first to devise an artificial production of fast protons. They bombarded lithium with these protons, and identified the products of the disintegration as alpha particles or helium nuclei.

$Lithium^7 + Hydrogen^1 (\text{proton}) = 2 Helium^4 (\alpha)$ . Of course these processes are not efficient in the sense of producing large quantities of a new element. Cockroft and Walton found that one alpha particle was produced for every billion protons at 250,000 volts. It has remained for American physicists at the

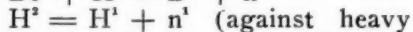
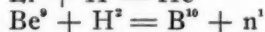
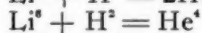
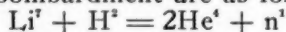
(continued on page 11)

## MODERN ALCHEMY

(continued from page 10)

University of California, Doctors Lawrence, Livingston, Henderson, and White, to improve greatly the experimental technique so that protons with energies up to three million electron-volts are produced and used in the disintegration of lithium, boron, and other elements. In their ingenious apparatus, looking like a kind of pill-box cut in two, protons from a filament in hydrogen gas are kept circling around in a magnetic field between two series of plates, with oscillating potential, so that the initial 4,000 volts accelerating force is augmented each time the proton crosses from one series of plates to the other, up to the million or more electron-volts. These energetic hydrogen hearts are then shot at a target, with the result that lithium or boron or other atomic nuclei cannot endure the onslaught. The effort has been made to give these projectiles greater and greater energies. It remained for some German investigators recently to show that disintegration can occur with protons with energies even as low as 29,000 electron volts.

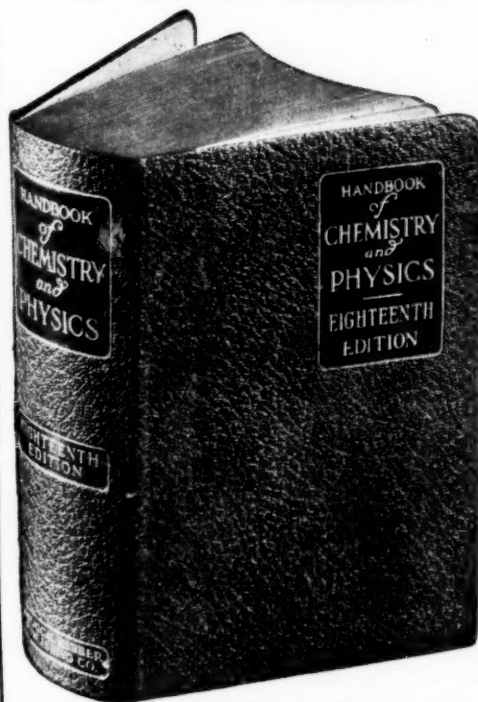
Still more remarkable are the disintegrations produced by deuterons, to which tremendous energies may be imparted in the Lawrence apparatus. Deuterium is derived from pure heavy water which is obtained by electrolytic fractionation of ordinary water. This heavy hydrogen is then ionized to form the charged deuterons to which enormous kinetic energy is artificially imparted until they are hurled against targets. Some of the nuclear disintegrations which result from deuteron bombardment are as follows:



metal targets). Neutron production by means of deuterons is several hundred times more efficient than the yield from alpha particles.

Only a few days ago Tuve and Hofstad at the Carnegie Institution in Washington accomplished another transformation of unusual interest. They found that—

(Continued on page 12)

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### LABORATORY ASSISTANTS

(Continued from page 7)

done. But since high grades have formed a basis for selection, much of an increase in grade might give the assistant a mark of one hundred or more. In the Gillespie Chemistry Department chenile monograms are awarded to the assistants at the end of their year of apprenticeship. These monograms cost as much as the athletic letters awarded in sports and are prized as highly by the students receiving them.

As no system is perfect, it is not to be expected that the laboratory assistant system will always operate with one hundred per cent efficiency; but after eight years of testing and carefully evaluating such a system it can definitely be stated that the problems and duties of an overworked science instructor may be considerably reduced, or entirely removed, through the intelligent use of carefully selected and thoroughly trained student laboratory assistants.

### SILVERPLATING AS A PROJECT

(Continued from page 8)

ject is not clean and the cleansing process should be repeated.

For silverplating, one liter of the plating solution may be prepared as follows: (1) dissolve 8.6 grams of silver nitrate in 500 cc. of distilled water; (2) dissolve 85 grams of potassium cyanide in a second portion of 500 cc. of distilled water; and (3) mix the solutions of silver nitrate and potassium cyanide.

Two or three dry cells may be used to furnish the electric current. The current flow can be controlled by an adjustable resistance placed in the circuit. The cleaned article to be plated is connected by copper wire with the negative pole, while a silver feeding plate (a silver coin may be used) is connected with the positive pole. The time needed for plating depends upon the thickness of the coating desired.

Some undesirable results may be obtained: for example, the silver may fail to stick, may be dark, or may have a dull luster. The failure of the metal to stick indicates that the metal to be plated was not chemically clean. If the plating is dark, too much current is flowing and

more resistance is needed in the circuit. If the surface has a dull luster, it indicates that the article was not well polished before it was plated.

For polishing the finished product, jeweler's rouge will be found especially useful.

### MODERN ALCHEMY

(continued from page 11)

Aluminum<sup>27</sup> + Helium<sup>4</sup> (alpha) = Silicon<sup>30</sup> + H<sup>1</sup> (proton). However, this took place only if alpha particles were very carefully "tuned" to the aluminum atoms, or had just the right amount of energy (600,000 volts) to penetrate or set into resonance the aluminum atomic hearts.

And so, in the light of these amazing developments in research of the past few months, including evidence of the transformation of matter into energy, or energy into matter, who can say that science is finished, and that everything of any importance has been discovered? In spite of the darkest days in economic history, surely these are great times in which we live. We are coming daily to a clearer knowledge of the universe, and to appreciation of the greatness of men's minds which can conceive such experiments and interpret them unmistakably in terms of the utterly smallest things in the universe. Certainly it is an overpowering inspiration to contemplate the fact that my mixing a little radium emanation with a little powdered beryllium in a test tube, or by spinning atomic nuclei around in a "pill-box" until great energies are added artificially, infinitely small projectiles, so powerful, with such terrific velocities, that the nuclei of atoms, seemingly among all things the most truly everlasting and unchanging, can be shattered. Nineteen hundred thirty-four has seen the return of the alchemist—but the most advanced and brilliant and modern scientists, who gives not a thought to changing lead to gold so as to become magically wealthy, but to achievements more priceless and spectacular.



**ENRICHED CHEMISTRY COURSE**

(Continued from page 8)

**Atoms and Molecules—What They Are**

Bragg, Sir William. Concerning the Nature of Things.

Harper and Brothers, New York.

Atoms of Which Things Are Made, Chapter 1.

Darrow, Floyd L. The Story of Chemistry.

Bobbs Merrill Company, Indianapolis, 1927.

After Alchemy, Chapter 2.

Hendrick, Ellwood. Everyman's Chemistry.

Harper and Brothers, New York, 1917.

Heart of the Thing, Chapter 2.

Kendall, James. At Home Among the Atoms.

Atom—Its Size and Weight, Chapter 8.

The Mighty Atom, Chapter 6.

Martin, Geoffrey. Triumphs and Wonders of Modern Chemistry.

D. Van Nostrand Company, New York, 1919.

The Underworld of Atoms, Chapter 2.

**Atomic Disintegration and Radio Active Materials.**

Clifford, James L. Experiments in Atomic Science.

Richard and Badger, The Gorham Press, Boston, '30. (See page 15.)

—:—

**A Book for Class and Club**

The historical aspect of chemistry often adds much interest to both class and club work. Students are interested in the type of apparatus used by the earlier chemists and in the experiments that lead to the discovery of much of our present day knowledge in this field. An interesting book that will supply information as to the apparatus and experiments of the earlier chemists is "Modern Alchemy" by Noyes and Noyes.

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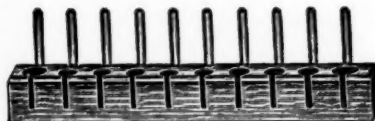
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### Discovery of the Composition of Water (Continued from page 4)

copper oxide, and the weight of the hydrogen from the difference between that and the weight of the water. In this and the following experiments the results are recalculated as the atomic weight of hydrogen, with  $O=16.00$  as the basis. As we now know that there are three kinds of oxygen, these values require a slight change. Their value was 1.00667.

Twenty years later, in 1842, Dumas spent many months in determining the ratio by the same method. His value was 1.00250. Dumas said he hoped this result was within one part in 300 or 400 of the truth. Because the result agreed closely with a result based on the relative densities of hydrogen and oxygen gases as determined by Regnault, the value was considered as quite accurate for about 40 years. Then it was discovered that Regnault's empty globe must have been compressed with a weight of several tons of air on the outside. Because of the air displaced the weight of

the empty globe was too heavy and there was a very considerable error, completely destroying the agreement with the value of Dumas.

Professor E. W. Morley worked for more than 15 years on the problem at Cleveland, Ohio. His experiments were carried through with a patience and painstaking accuracy which has never been excelled. He weighed his hydrogen absorbed in palladium, his oxygen in globes and he also weighed the water formed by their combination. His value was 1.00762. Morley also determined the weight of a liter of hydrogen, using 40 liters of the gas, and by taking the ratio of combination by volume and the weight of a liter of oxygen, which he also determined, a result closely agreeing with the other was secured.

Cooke and Richards weighed four liters of hydrogen in a globe, burned it and weighed the water formed. Before they published their results they made the same mistake as Regnault, in regard to the weight of the hydrogen, but were

(Continued on page 15)

**Discovery of the Composition of Water**

(Continued from page 14)

able to correct the mistake by determining the compression of their globe when there was a pressure of an atmosphere on the outside. Their corrected value was 1.00826.

In 1888 it occurred to me that I could weigh an evacuated apparatus containing copper oxide, pass into the apparatus hydrogen gas while heating the oxide, and condense the water formed within the same apparatus. The gain in weight gave the weight of the hydrogen and the loss in weight after the water was removed gave the weight of the oxygen. This gave a fairly accurate result but an error in the calculation was suspected later which if corrected, would bring the result very close to Morley's. In 1904-7 I was able to repeat the work at the Bureau of Standards in Washington and then found the value 1.00787. The value now given in atomic weight tables is 1.0078 and, taken with Morley's value, I think we have some reason to hope that this is accurate within one part in 5000.

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**Choice Books for the Library**

A comprehensive article entitled, "Report of the Committee on Chemistry Libraries", is to be found in the February issue of the *Journal of Chemical Education*. This report gives a list of books and magazines which are recommended for chemistry libraries. The list includes popular books, text books, and laboratory manuals, and books on teaching and on the history of chemistry. While the report was prepared primarily for high school teachers, yet college and university teachers will also find it valuable.

The report is made by V. S. Culp, W. A. Noyes, and Rufus D. Reed.

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**ENRICHED CHEMISTRY COURSE**

(Continued from page 13)

Phosphorescent Effect, pp. 49-53.

Photography with Radioactive Radiations, pp. 19-25.

Evidences of Radioactive Disintegration Using Uranium Compounds, pp. 56-65.

(Continued next issue)

*Recommended By*  
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**The Scientific Book Club Review**  
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By

WILLIAM A. NOYES (University of Illinois)  
 and

W. ALBERT NOYES (Brown University)

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